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09/856,761	05/23/2001	Shmuel Akerman	032/02161	3117

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EXAMINER	
SEALEY, LANCE W	

ART UNIT	PAPER NUMBER
2671	8

DATE MAILED: 07/21/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/856,761	AKERMAN ET AL.	
	Examiner	Art Unit	
	Lance W. Sealey	2671	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on *19 May 2004* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-49,51 and 52* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-5,13,19,20,22,23,28-30,32-38,40-49,51 and 52* is/are rejected.

7)☒ Claim(s) *6-12,14-18,21,24-27,31 and 39* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☒ Interview Summary (PTO-413) Paper No(s). *8* .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

DETAILED ACTION

Allowed and Allowable Subject Matter

1. Claims 6-12, 14-18, 21, 24-27, 31 and 39 are objected to as being dependent upon rejected base claims, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

2. The following is a statement of reasons for the indication of allowable subject matter: No prior art suggests or implies, in a method of forming a high spatial resolution perspective rendering from a low spatial resolution voxel data set, calculating said surface lighting contribution during ray casting (claim 6); providing an index array indicating for at least some of said voxels if a class-boundary does not pass near the voxel (claim 8); calculation of surface lighting in the determination of the surface lighting contribution (claim 12); sampling points are separated by a step size which is dependent on the opacity value at the sampling points (claim 14); providing a definition of voxel value intervals for each class prior to said ray casting (claim 18); cubic interpolation for nearby points and linear interpolation for far points (claim 21); performing (f) in claim 1 wherein (f) comprises sparely casting rays and determining whether to cast one additional ray between cast rays (claim 24); wherein the density of raycasting is progressively increasing and additional cast rays are cast to progressively generate nested levels of resolution in the formed image (claim 31); and accumulation of opacity comprises updating a storage value CT as follows: CT=CT*T^step_size, where T is a transparency value corresponding to the opacity value (claim 39). Claim 7 is allowable because claim 6 is allowable; claims 9-11 are allowable because claim 8 is allowable; claim 15-17 are

allowable because claim 14 is allowable; and claims 25-27 are allowable because claim 24 is allowable.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. § 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-5, 13, 22-23, 29, 32-38, 41-49 and 51-52 are rejected under 35 U.S.C. 103(a) as being unpatentable by Foley et al., Computer Graphics: Principles and Practice Second Edition in C ("Foley").

5. Foley, a computer graphics textbook, discloses, with respect to claim 1, a method of forming a high spatial resolution perspective rendering from a low spatial resolution voxel data set, comprising:

(a) raycasting at least one ray from a predetermined location (eyepoint, p.1036, last paragraph, second sentence) into the voxel space (p.1036, last paragraph, second sentence) by sampling points along said ray in a space (p.1036, last paragraph, second sentence).

(b) accumulating the effect of opacity along the ray path (p.1036, last paragraph, second sentence), using opacity values at said sampling points (p.1036, last paragraph, third

sentence; opacity values are "used" to decide when R, G, B and O values should no longer be accumulated), into a ray storage value (p.1036, last paragraph, third sentence; O value is compared to 1 in an effort to decide when to stop accumulation of R, G, B and O values).

(c) associating points along the cast ray with material classes (p.1036, last paragraph, second sentence; any R, G, B or O value, or a combination of same, corresponding to a point sampled by the ray, constitutes a "material class");

(d) determining if a ray passes from a point in a first material class to a point in a second material class (p.1036, last paragraph, second sentence; if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a "material class", then a ray sampling R, G, B and O values from one point to another is "passing from a point in a first material class to a point in a second material class");

(e) accumulating a surface lighting contribution associated with a boundary between the two classes into said ray storage value if the ray is determined to pass between classes (Foley does not specifically disclose accumulating a surface lighting contribution. However, p.1036, last paragraph, second sentence, discloses a boundary between two material classes (see the rejection of 1(c) above for the disclosure in Foley of material classes, and a boundary is disclosed because the dictionary definition of a boundary is a separation between two groups, or classes) and passing between classes (see the rejection of claim 1(d) above). Therefore, it would have been obvious to one skilled in the art at the time this invention was made that if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a "material class", then the

average of visualization values between any two adjacent points separated by a boundary can constitute a "surface lighting contribution");

(f) repeating at least (a), (b), (d) and (e) for a plurality of cast rays (p.1036, last paragraph, second sentence; starting this sentence with the words "for each ray" renders obvious the likelihood the expectation that a plurality of rays will be cast); and

(g) forming a high spatial resolution perspective rendering from said determining ray storage values ("Ray-tracing architectures", p.910-11, especially "Component parallelism"; extremely realistic images are obvious examples of high spatial resolution perspective rendering).

6. Concerning claims 2 and 3, Foley discloses determining the location of boundaries set at a position between two points of different material opacity classes during ray casting (p.1036, last paragraph, second sentence; if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a "material class", then the separation between each point sampled by the ray constitutes a boundary, and boundaries are set at a position between two points of different material opacity classes).

7. With respect to claim 4, Foley discloses boundaries between material opacity classes determined by examining at least one additional sampling point between the two points of different classes (p.1036, last paragraph, second sentence; if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a "material class", then the sampling of any point between two other points on the ray fulfills this claim).

8. Concerning claim 5, Foley discloses examining at least one additional sampling point between the points of different classes comprising repeating examining sampling points between points of different classes until a desired precision of boundary determination is achieved (p.1036, last paragraph, second sentence; if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a "material class", then the boundary has been determined with a precision: the boundaries enclose one point sampled on the ray).

9. Regarding claim 13, Foley discloses stopping ray casting if said accumulated opacity is over a threshold at p.1036, last paragraph, third sentence.

10. Concerning claim 22, Foley does not specifically disclose the predetermined location from which the ray is cast as being within the voxel, but the disclosure of this element is obvious because even if a ray starts from a predetermined location outside the voxel, it passes through voxels, which means at one point it is inside a voxel space continuing through the voxel space. At that point the determining location is within the voxel space. (See p.1036, last paragraph, second sentence).

11. Regarding claim 23, Foley discloses the voxel data set comprising a medical imaging data set ("the volume array of data representing the field", p.1038, first full paragraph, second sentence).

12. Concerning claim 29, Foley does not explicitly disclose progressively increasing the density of raycasting. But it would be obvious to one skilled in the art at the time this invention was made to progressively increase the density of raycasting because the second paragraph of p.793 describes a procedure in which rays are sent from each light source as

a preprocessing measure, then a conventional ray is then cast which would reasonably be more focused with the ability to penetrate denser objects.

13. With respect to claim 32, Foley discloses rendering a formed perspective in a display (Plate I.1).

14. Regarding claim 33, Foley discloses defining a window in or near the voxel space through which to cast rays (Figure 15.55, p.701).

15. Foley does not specifically disclose a window through which rays are that is perpendicular to a provided orientation vector (claim 34), a flat, rectangular window (claim 35), a curved window (claim 36), a window defined by pixels in a uniformly shaped rectangular grid (claim 37), or a window defined by pixels using coordinates which are one of circular coordinates, elliptical coordinates and another conic projection of coordinates (claim 38).

16. However, Foley describes ray casting as "determin[ing] the visibility of surfaces by *tracing imaginary rays of light from the viewer's eye to objects in the scene*" (Section 15.10, p.701, italics added by examiner for emphasis). In the same section (Fig.15.56), ray casting is accomplished through a window. Foley also presents tracing rays of light from a light source as an example of ray casting (p.793). Therefore, since examples can be presented in everyday life of each type of window disclosed in claims 34-38, and Foley discloses ray casting through a window, it would be obvious to one skilled in the art at the time the invention was made that ray casting could be accomplished through virtually any type of window. Therefore claims 34-38 are rejected.

17. Concerning claim 41, Foley discloses the voxel data set generated by one of CT

(Computerized Tomography), MRI (Magnetic Resonance Imaging), Ultrasound, a geophysical survey, a meterological survey, a scientific simulation, an animation model having more than two dimensions and a set of simultaneous equations (CT; see p.1038, first full paragraph, and p.1039, first full paragraph).

18. Regarding claim 42, Foley discloses each voxel having associated therewith a visual representation value (composite colors and opacities) and comprising determining a visualization value (color/opacity) associated with a sampled point from the voxel associated visual representation values; and accumulating said point associated visualization value into said stored value (p.1038, third full paragraph).

18. With respect to claims 43 and 44, Foley discloses the visual representation value associated with the voxel as being a gray scale (claim 43)/color value (claim 44)(p.1038, first full paragraph).

19. With respect to claim 45, Foley does not explicitly disclose accumulating said point associated visualization values by selectively accumulating values based on front surface detection. However, it would be obvious to a person skilled in the art to accumulate visualization values based on front surface detection because the first sentence of Section 15.10, p.701, states that raycasting determines the visibility of surfaces by tracing imaginary rays of light from the viewer's eye to the objects in the scene. Presumably this would mean the front surfaces of the objects.

20. Concerning claims 46 and 47, Foley discloses said point associated visualization value comprising a volume lighting value (claim 46)/surface lighting value (claim 47) (p.1038, first full paragraph—color always has a lighting value, and when a volume is lit

its surfaces are lit).

21. With respect to claim 48, Foley discloses the advancement along a ray coordinated with an opacification process (p.1036, last paragraph).

22. Concerning claim 49(a), Foley discloses the voxel data set ("the volume array of data representing the field", p.1038, first full paragraph, second sentence) and the existence of memory to store the voxel data set is inherent; regarding claim 49(b), it would have been obvious at the time this invention was made to use a computer processor for applying the method of forming a high spatial resolution perspective rendering from a low spatial resolution voxel data set, and with respect to claim 49(c), it would have been obvious to disclose a second memory for storing said formed perspective rendering. At the time this invention was made, the use of computer processors and memory for high spatial resolution perspective rendering was assumed.

23. Regarding claim 51, Foley discloses determining using opacity values of points if a ray passes from a point in a first material class to a point in a second material class (p.1036, last paragraph, second sentence: if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a "material class", then a ray sampling R, G, B and O values from one point to another is "passing from a point in a first material class to a point in a second material class"; and, if an opacity value is being accumulated, it is being "used").

24. With respect to claim 52, Foley discloses the material classes belonging to a plurality of material classes (p.1036, last paragraph, second sentence: if any R, G, B or O value, or combination of same, corresponding to a point sampled by the ray, constitutes a

"material class", then a ray sampling two or more points has come in contact with a plurality of material classes).

25. In view of the foregoing, the examiner concludes that claims 1-5, 13, 22-23, 29, 32-38, 41-49 and 51-52 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Foley.

26. Claims 19-20 and 28 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Foley and further in view of Knittel et al. ("Knittel," U.S. Pat. No. 6,297,799).

27. Foley does not disclose, with respect to claim 19, the opacity value of at least some of the sampling points determined by interpolating between voxels near said point and transforming said interpolated voxel value into an opacity value for said point. These elements are taught by the Knittel real-time volume rendering system. Interpolating between voxels at said point is disclosed at col.4, ll.32-43, and transforming said interpolated voxel value into an opacity value for said point is disclosed at col.4, ll.20-31.

28. Therefore, it would have been obvious to one of ordinary skill in the art to have modified the Foley raycasting in view of the Knittel volume rendering system. Such a modification to Foley would increase quality and realism (Knittel, col.2, ll.25-29).

29. Regarding claim 20, it would have been obvious that interpolation would be dependent on a distance between said sampled point and said vantage point because the definition of interpolation is calculating a value between two other values which is a fixed distance between one value (sampled point) and the other value (vantage point).

30. Concerning claim 28, Knittel discloses interpolating between stored values of cast rays at col.4, ll.18-22.

31. In view of the foregoing, the examiner concludes that claims 19-20 and 28 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Foley in view of Knittel.

32. Claims 30 and 40 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Foley in view of Ogata et al. ("Ogata", U.S. Pat. No. 6,313,841).

33. With respect to claim 40, Foley does not disclose parallel cast rays. However, this element is disclosed by the Ogata volume rendering system at col.1, ll.11-16.

34. Therefore, it would have been obvious to one of ordinary skill in the art to have modified the Foley raycasting in view of the Ogata method of casting rays in parallel. This would produce a two-dimensional projection of a three-dimensional dataset, allowing the viewer to focus on specific details (Ogata, col.1, ll.11-16).

35. Concerning claim 30, Foley does not explicitly disclose progressively increasing the density of raycasting. But it would be obvious to one skilled in the art at the time this invention was made to progressively increase the density of raycasting because the second paragraph of p.793 describes a procedure in which rays are sent from each light source as a preprocessing measure, then a conventional ray is then cast which would reasonably be more focused with the ability to penetrate denser objects. And Ogata discloses parallel cast rays.

36. In view of the foregoing, the examiner concludes that claims 30 and 40 have been rendered unpatentable by Foley and Ogata.

Response to Remarks

37. Before a response is given to the remarks, it should be noted that the applicants' amendments amount to changing the term "surface lighting contribution" to "surface

lighting contribution" in order to use a term in the claims which is the same as the term used in the specification. However, since the old term "surface lighting contribution" was not found to be allowable, merely changing the term to "surface lighting contribution" is not going to make the claims allowable.

38. With respect to the applicants' remark concerning claim 1 that Foley does not teach or suggest accumulating a lighting contribution of a surface associated with a boundary between two classes into the ray storage value (claim 1(e)), item 7 above explains how Foley discloses this element.

Action is Final

39. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

40. A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Conclusion

Any inquiry concerning this communication or earlier communications from the Office should be directed to the examiner, Lance Sealey, whose telephone number is (703) 305-0026. He can be reached Monday-Friday from 7:00 am to 3:30 pm EDT.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mark Zimmerman, can be reached at (703) 305-9798.

Any response to this action should be mailed to:

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P.O. Box 1450

Alexandria, VA 22313-1450

or faxed to:

(703) 872-9306

Hand-delivered responses should be brought to Crystal Park II, 2121 Crystal Drive, Arlington, VA, Sixth Floor (Receptionist).

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